

SAN ANTONIO
SIGGRAPH
2002

Jigsaw Image Mosaics





Junhwan Kim and Fabio Pellacini
Cornell University

27 July 2002

1.Motivation 2. Related Work 3. Framework 4. Algorithm 5.Results 6.Conclusions

Goal



- ✳ Allow tile deformation
- ✳ Arbitrarily-shaped container and tiles

Jigsaw Image Mosaics - Junhwan Kim and Fabio Pellacini

1.Motivation 2. Related Work 3. Framework 4. Algorithm 5.Results 6.Conclusions

Goal

Algorithm Criteria

- ✳ Visually pleasing result
- ✳ Acceptable computational cost
- ✳ Little user effort

Jigsaw Image Mosaics - Junhwan Kim and Fabio Pellacini

1.Motivation 2. Related Work 3. Framework 4. Algorithm 5.Results 6.Conclusions

Outline

- ✳ Motivation
- ✳ Related Work
- ✳ Framework
- ✳ Algorithm
- ✳ Results
- ✳ Conclusions

Jigsaw Image Mosaics - Junhwan Kim and Fabio Pellacini

1.Motivation 2. Related Work 3. Framework 4. Algorithm 5.Results 6.Conclusions

Motivation

Fruit Face

Giuseppe Arcimboldo
1527-1593

Summer
1573

Oil on canvas
76x64cm

Louvre Museum
Paris, France

Jigsaw Image Mosaics - Junhwan Kim and Fabio Pellacini

1.Motivation 2. Related Work 3. Framework 4. Algorithm 5.Results 6.Conclusions

Related works

Mosaicing algorithms

- ✳ Photomosaics [Finkelstein, A. and Range]
- ✳ Simulated Decorative Mosaics [Hausner]
- ✳ Escherization [Kaplan and Salesin]

Packing algorithms [Milenkovic]

Jigsaw Image Mosaics - Junhwan Kim and Fabio Pellacini

1.Motivation
2.Related Work
3.Framework
4.Algorithm
5.Results
6.Conclusions

Framework

Energy minimization

$$E = w_C \cdot E_C + w_G \cdot E_G + w_O \cdot E_O + w_D \cdot E_D$$

Container

Trying 1st tile...

Trying 2nd tile...

Trying 3rd tile...

Trying 4th tile...

Trying 5th tile...

Legend

Container to be filled

Container filled

Tiles

Color mismatch

Gap region

Overlap region

Shape mismatch

Accepted tile

Jigsaw Image Mosaics - Junhwan Kim and Fabio Pellacini

1.Motivation
2.Related Work
3.Framework
4.Algorithm
5.Results
6.Conclusions

Framework

Energy minimization

- ✦ Easy to control
- ✦ Easy to extend
- ✦ Little user effort

Jigsaw Image Mosaics - Junhwan Kim and Fabio Pellacini

1.Motivation
2.Related Work
3.Framework
4.Algorithm
5.Results
6.Conclusions

Basic Algorithm Overview

a) Initial container image

b) Tile contours after tile placement

c) Tile contours after tile refinement

d) Final Jigsaw

Phase 1: Placing tiles

Phase 2: Refining tiles

Phase 3: Adjusting images

Jigsaw Image Mosaics - Junhwan Kim and Fabio Pellacini

1.Motivation
2.Related Work
3.Framework
4.Algorithm
5.Results
6.Conclusions

Basic Algorithm Packing

Packing

$$E = w_C \cdot E_C + w_G \cdot E_G + w_O \cdot E_O + w_D \cdot E_D$$

a) Initial container

b) Container with placed tile

c) Container for next iteration

Jigsaw Image Mosaics - Junhwan Kim and Fabio Pellacini

1.Motivation
2.Related Work
3.Framework
4.Algorithm
5.Results
6.Conclusions

Basic Algorithm Packing

a) Container

b) Available Tiles

Place 1st tile

Cannot place next

Backtrack

Try again 1st tile

Place next

Done

Jigsaw Image Mosaics - Junhwan Kim and Fabio Pellacini

1.Motivation
2.Related Work
3.Framework
4.Algorithm
5.Results
6.Conclusions

Basic Algorithm Refinement

Packing

$$E = w_C \cdot E_C + w_G \cdot E_G + w_O \cdot E_O + w_D \cdot E_D$$

Refinement

Active contours [Kass et al. 1987]

- ✦ Internal force: Maintain original shape
- ✦ External force: Reduce Gap and Overlap

Jigsaw Image Mosaics - Junhwan Kim and Fabio Pellacini

1.Motivation 2. Related Work 3. Framework 4. Algorithm 5.Results 6.Conclusions

Basic Algorithm Refinement

a) Initial contours b) Intermediate contours c) Converged contours

Jigsaw Image Mosaics - Junhwan Kim and Fabio Pellacini

1.Motivation 2. Related Work 3. Framework 4. Algorithm 5.Results 6.Conclusions

Basic Algorithm Warping

Image warping technique [Arad et al. 1994]

- ✳ Radial basis function
- ✳ Affine transform

Jigsaw Image Mosaics - Junhwan Kim and Fabio Pellacini

1.Motivation 2. Related Work 3. Framework 4. Algorithm 5.Results 6.Conclusions

Algorithm Optimization

- ✳ Placing a tile
- ✳ Branch-bound with Look-ahead
- ✳ Geometric hashing

Jigsaw Image Mosaics - Junhwan Kim and Fabio Pellacini

1.Motivation 2. Related Work 3. Framework 4. Algorithm 5.Results 6.Conclusions

Algorithm Optimization Placing a tile

Legend

- CVD connected graph
- CVD cells
- Selected position: only two neighbors in the CVD graph

Jigsaw Image Mosaics - Junhwan Kim and Fabio Pellacini

1.Motivation 2. Related Work 3. Framework 4. Algorithm 5.Results 6.Conclusions

Algorithm Optimization Look ahead

Packing

$$E = w_C \cdot E_C + w_G \cdot E_G + w_O \cdot E_O + w_{LA} \cdot E_{LA}$$

Packing w/ Look ahead

$$E_{LA} = w_A \cdot area + (1 - w_A) \cdot length^2$$

Jigsaw Image Mosaics - Junhwan Kim and Fabio Pellacini

1.Motivation 2. Related Work 3. Framework 4. Algorithm 5.Results 6.Conclusions

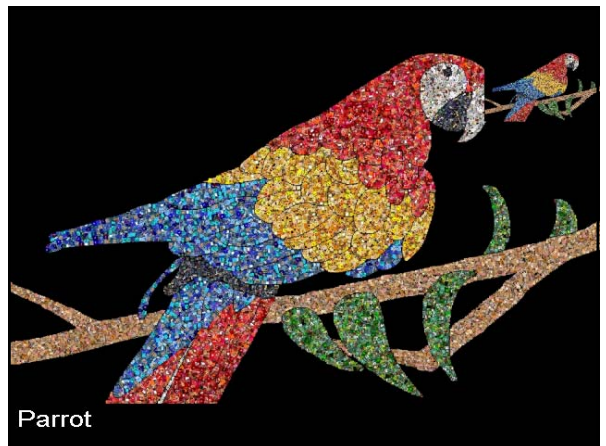
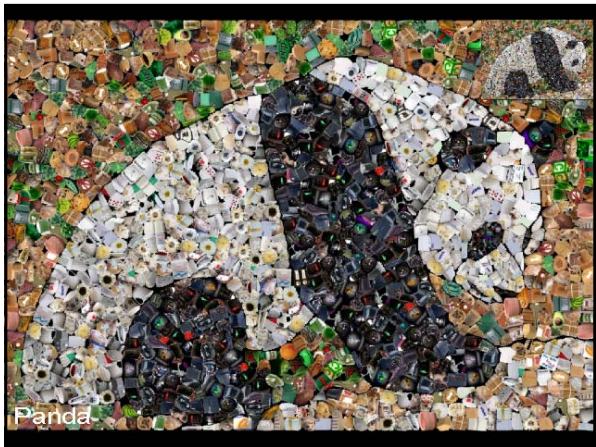
Algorithm Optimization Geometric Hashing [Wolfson and Rigoutsos, 1997]

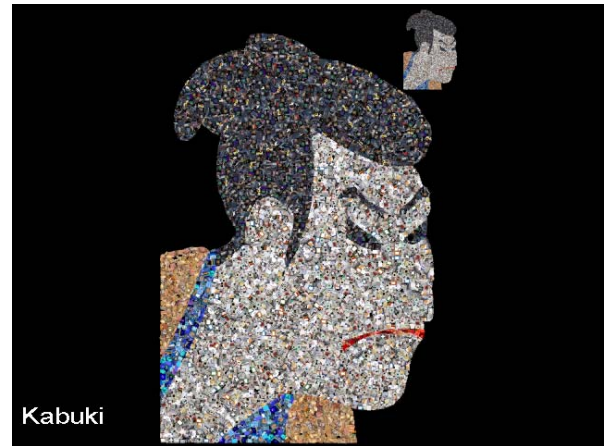
Legend

- Container contour
- Tile contour
- Container and tile contour overlap: cast a vote

a) Bad tile: 15 votes b) Good tile: 22 votes

Jigsaw Image Mosaics - Junhwan Kim and Fabio Pellacini





1. Motivation 2. Related Work 3. Framework 4. Algorithm 5. Results 6. Conclusions

Conclusions

Contributions

- ✦ New kind of mosaic
- ✦ General framework for mosaics
- ✦ Effective algorithm

Future work

- ✦ Faster algorithm
- ✦ Extension to 3D

Jigsaw Image Mosaics - Junhwan Kim and Fabio Pellacini

1. Motivation 2. Related Work 3. Framework 4. Algorithm 5. Results 6. Conclusions

Acknowledgements

- ✦ **Comments:** Eva Tardos, Klara Kedem, Paul Chew, Shimon Edelman, James E. Cutting, Vladimir Kolmogorov, Amy Gale
- ✦ **Encouragement:** Ramin Zabih, Donald P. Greenberg
- ✦ **Proofreading:** Peggy Anderson, Parag Tole, Steven Westin
- ✦ **Talk preparation:** Younga Kim, John Lee
- ✦ **Software:** Alejo Hausner

Jigsaw Image Mosaics - Junhwan Kim and Fabio Pellacini

1. Motivation 2. Related Work 3. Framework 4. Algorithm 5. Results 6. Conclusions

Acknowledgements

- ✦ **Pictures:** Alejo Hausner, Adam Finkelstein, Craig S. Kaplan, Victor J. Milenkovic
- ✦ **Images:** CAVE Lab at Columbia University, coolarchive.com
- ✦ **Financial support:** NSF IIS-9900115, NSF CCR-0113371, Microsoft Research, NSF Science and Technology Center for Computer Graphics and Scientific Visualization
- ✦ **Special thanks:** Stephen Spencer, John F. Hughes

Jigsaw Image Mosaics - Junhwan Kim and Fabio Pellacini